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(54) Dual anode flat panel electrophoretic display apparatus.

(57) An electrophoretic display has a grid cathode matrix arrangement consisting of a first plurality of parallel conductive lines insulated from a second plurality of parallel conductive lines transverse to said first plurality. Located with respect to the grid and cathode lines are first and second anode structures. The first anode is remote from the second with the second anode overlying the gird lines of the display and insulated therefrom. The second anode is biased to implement typical HOLD and ERASE modes independent of the first anode.

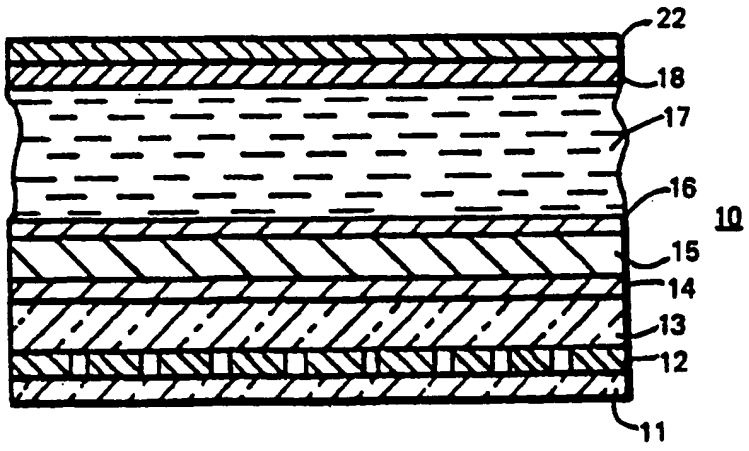

FIG. 1

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the flat panel display while further reducing the anode voltage required during the WRITE and HOLD cycles.

Summary of the Invention

In an electrophoretic display of the type having a cathode matrix comprising a plurality of parallel lines arranged in a given direction, with a grid matrix insulated from said cathode matrix and comprising a plurality of parallel lines each perpendicular to said cathode lines to form an X-Y addressing matrix with a conventional anode electrode separated from said X-Y matrix with the space between said anode electrode and said X-Y matrix accommodating an electrophoretic dispersion including pigment particles suspended in a fluid, the improvement therewith of an additional anode electrode comprising a plurality of parallel lines each associated with and insulated from a respective grid line with said additional anode operative when biased to control the path of said pigment particles to and from said grid and cathode matrix and to allow excess pigment to remain at said conventional anode electrode.

Brief Description of the Figures

FIG.1 is a cross sectional view of an electrophoretic display according to this invention.

FIG. 2 is a cross sectional view of the display of FIG. 1.

FIG. 3 is a front plan view of a typical grid line and also a configuration of a typical local anode line.

Detailed Description of the Figures

Referring to Fig. 1, there is shown a cross sectional view of an electrophoretic display 10 constructed according to the teachings of this invention.

As one can see from FIG. 1, the display 10 basically appears as prior art displays with the exception that there is an additional electrode 16 which will be designated as a local anode as compared to the remote anode 18. The remote anode 18 is the conventional anode associated with the prior art electrophoretic displays. As one will understand, the electrophoretic display as described in many of the prior art patents as above indicated has a viewing area which includes a bottom glass sheet 11. Disposed upon sheet 11 are a plurality of cathode lines 12. These cathode lines 12 are directed in the horizontal or vertical direction and are essentially parallel to one another to form a matrix or grid of lines. Separated from the cathode lines by means of a photoresist or insulator 13 is a plurality of grid lines 14. The grid lines are disposed transverse to the cathode lines and intersect each cathode line to provide an XY matrix arrangement where by a typical pixel area is accessed by addressing a grid and cathode line and thereby providing a desired potential at the intersection between the two lines. This potential causes the migration of electrophoretic particles which are suspended in the electrophoretic suspension and which particles migrate from the grid and cathode structure to the anode 18. The anode 18 is a very thin layer of metal deposited upon a planar glass member 22 according to prior art teachings.

Referring to FIG. 2, there is shown a side cross sectional view of the electrophoretic display. The cathode lines 12 which are thin layers of ITO are deposited upon the glass substrate 11 with the grid lines 14 being perpendicular thereto and insulated from the cathode line by means of insulator layer 13. The thickness of the insulator areas as 13 and 15 is approximately 3 microns with the distance from the top of insulator 15 to the remote anode electrode 18 being about 7 mils. As seen more clearly in FIG. 2, each grid line 14 is separated from a local anode line 16 by means of an insulator layer 15.

In this manner the local anode 16 is of the same exact configuration as the grid structure 14. The anode 16 is separated from the grid by the insulating layer 15 and is configured the same as the grid structure. Thus, there are as many anode segments as there are grid segments. Each segment of the anode can have the same exact configuration as the grid. For example, U.S. 4,742,345 describes a grid structure fabricated with respect to the cathode structure in the configuration depicted in FIG. 3. As one can see from FIG. 3, each of the grids is fabricated by utilizing deposited metal on an insulator whereby a top conductive area or contact area 30 is provided which conductive area 30 is above a bottom conductive area 31. Disposed between areas 30 and 31 are a series of tines 32 which are grid conductors.

As one can understand, the parallel conductor members 32 as connected in parallel by the contact pair 30 and 31 provide a plurality of intersecting points for each of the grid structures with respect to the cathode line. The advantage of such an arrangement has been fully explained and described in U.S. 4,742,345. If the grid structure of FIG. 3 is employed then the anode structure 16 will follow the grid structure. In this manner it is seen that the local anode 16 may consist of a plurality of

the prior art erasing mode which occurred at the remote anode 18. The panel is fabricated utilizing the same techniques as evidenced by the prior art. Thus the display shown is operated by first providing the HOLD function from the remote anode 18 and thereafter ERASING and HOLDING from the local anode 16.

As one can ascertain from referring to U.S. 4,742,345, the cathode configuration is deposited upon the glass sheet 11 employing ITO and is constructed in the same manner as implemented in previous flat panels. An insulator which is a photoresist is applied to the cathode structure and the insulator is then coated with a thin layer of metal (metal 1). This metal layer may be chrome or some other material.

An insulator is applied to the metal layer and a thin layer of another metal (metal 2) is then applied to the insulator. This other metal may be nickel, aluminum, or some other metal. A layer of photoresist is applied to the second metal layer and is patterned in the usual way utilizing the grid mask. The metal layer 2 is then etched using a suitable etching solution depending upon the properties of the metal. The insulating layer between the first metal layer and the second metal layer is plasma etched. Using a suitable etching solution, the metal layer 1 is etched. It is indicated that the first metal layer and the second metal layer are selected such that the etching solution for the first metal layer does not effect the second metal layer. There are many solutions which will etch certain materials while not etching others.

The insulating layer between metal layer 1 and the cathode is next plasma etched. The metal in the chip area is etched leaving only the insulator between metal layer 1 and metal layer 2 and the insulator between metal layer 1 and the cathode. Prior to assembly a thin film of S_iO_2 is deposited on the entire surface except for the cathode and grid chip areas. The display parts comprising the structure indicated in FIG. 2 are assembled using appropriate spacers. The insulator on the surface of the first metal layer is removed and the flat panel is ready to receive the chips. The prior art panels, including the chips of the panel are further described in conjunction with the prior art patents.

The difference between the structure here and those of the prior art is the inclusion of an additional and different anode structure which is a series of lines congruent with and insulated from the grid lines. The second anode line structure can have all lines connected together at both top and bottom as described above or each of the anode lines can be separately addressed. The anode is for example fabricated from aluminum with the grid being fabricated from chrome. In this manner one can utilize different etchants to form the local anode structure 16 as compared to the typical grid structure 14 and hence obtain all the benefits of the above-noted structure.

Claims

1. In an electrophoretic display of the type having a cathode matrix comprising a plurality of parallel lines arranged in a given direction, with a grid matrix insulated from said cathode matrix and comprising a plurality of parallel lines each perpendicular to said cathode lines to form an X-Y addressing matrix with a conventional anode electrode separated from said X-Y matrix with the space between said anode electrode and said X-Y matrix accommodating an electrophoretic dispersion including pigment particles suspended in a fluid, the improvement therewith of:
an additional anode electrode comprising a plurality of parallel lines each associated with and insulated from a respective grid line with said additional anode operative when biased to control the path of said pigment particles to and from said grid and cathode matrix and to allow excess pigment to remain at said conventional anode electrode.

2. The electrophoretic display according to Claim 1, wherein said additional anode lines are of the same configuration as said grid lines.

3. The electrophoretic display according to Claim 2, wherein said grid lines are fabricated from chrome with said additional anode lines fabricated from aluminum.

4. The electrophoretic display apparatus according to Claim 1, wherein said additional anode lines are connected together.

5. The electrophoretic display according to Claim 1, wherein groups of said anode lines are connected together to enable selective ERASING of said display.

6. The electrophoretic display according to Claim 1, wherein said additional anode lines as insulated from said grid lines are separated therefrom by between 2-5 microns.

7. The electrophoretic display according to Claim 6, wherein each one of said grid lines is of a tine-like configuration comprising a plurality of parallel lines coupled together at a top contact and a bottom contact.

8. An electrophoretic display panel apparatus, comprising:
a planar member,
a first plurality of conductive lines deposited in a first direction of said planar member, each of said first plurality of conductive lines being disposed in parallel on said planar member,
a second plurality of conductive lines disposed in a second direction on said planar member with said

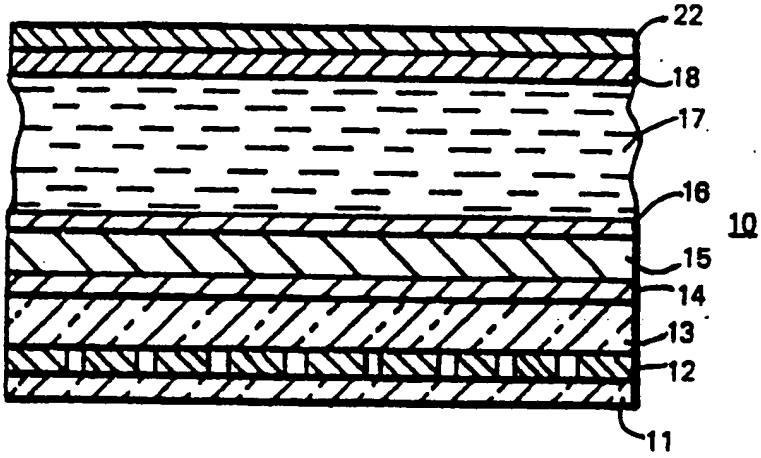

FIG. 1

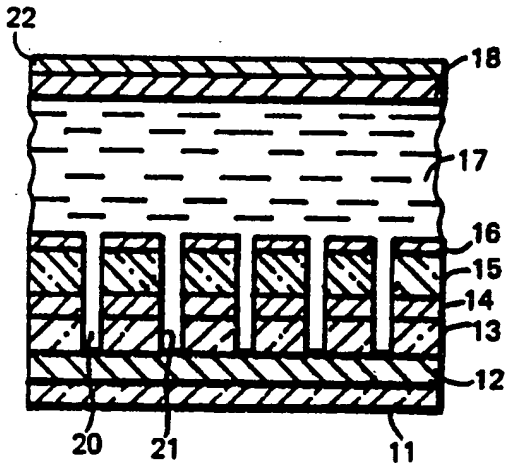

FIG. 2

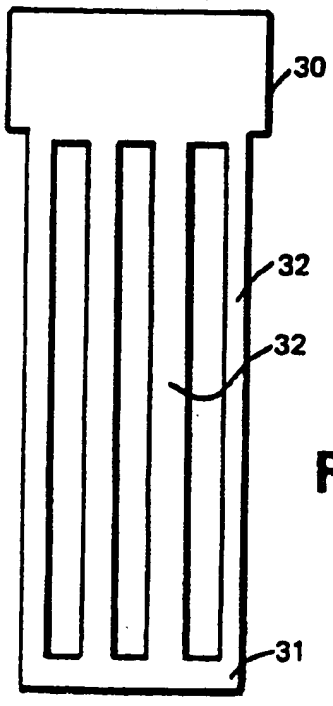

FIG. 3